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SCREENING OF INSECTICIDES FOR USE IN SASKATOON ORCHARDS TO REDUCE RISK OF INSECT PEST RESISTANCE TO DECIS AND TO INCREASE GROWER SAFETY

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SCREENING OF INSECTICIDES FOR USE IN SASKATOON ORCHARDS TO REDUCE RISK OF INSECT PEST RESISTANCE TO DECIS AND TO INCREASE GROWER SAFETY

ADF Project # 19990318

Final Report – January 30, 2003

Richard St-Pierre, Ph.D.
Research Scientist & Director
Native Fruit Development Program

Department of Plant Sciences
University of Saskatchewan
Saskatoon

1. Abstract/Summary

The objective of this project was to screen dormant oil (Bartlett's Superior 70 Oil), cyhalothrin-lambda (Matador 120 EC), carbaryl (Sevin XLR Plus), spinosad (Success 480 SC), and *Bacillus thuringiensis subsp. kurstaki* (DiPel 2X DF) for use in saskatoon orchards. The project determined that: a) Matador 120 EC was somewhat effective in controlling numbers and/or damage associated with thrip, leaf roller caterpillars, sawfly larvae and bud moth larvae; b) DiPel 2X DF provided partial control of bud moth larvae and leaf rolling caterpillars; and c) Success 480 SC controlled thrips, bud moth, leaf roller caterpillars, and sawfly larvae. Assessment for minor use registration of these insecticides is in progress. Sevin XLR Plus was deleted from the study on the advice of the Pest Management Regulatory Agency as new crop registrations for this product were being restricted. The use of Bartlett's Superior 70 Oil was very effective at controlling larval bud moth numbers and damage. As a result, minor use registration was granted for the use of Bartlett's Superior 70 Oil on saskatoon.

2. Executive Summary

The objective of this project was to screen a number of alternative insecticides suitable for use in saskatoon orchards for efficacy of control of insect pests of saskatoon. The insecticides screened included dormant oil (Bartlett's Superior 70 Oil), cyhalothrin-lambda (Matador 120 EC), carbaryl (Sevin XLR Plus), spinosad (Success 480 SC), and *Bacillus thuringiensis subsp. kurstaki* (DiPel 2X DF). At the beginning of this study, only one insecticide, Decis 5.0 EC, was registered for use against aboveground insect pests in bearing saskatoon orchards. The registration of one or more additional insecticides was important to reduce the risk of insect pests developing resistance to Decis 5.0 EC, to combat increasing problems from spider mites that have resulted from the use of Decis 5.0 EC, and to increase grower safety because Decis 5.0 EC is a relatively toxic insecticide.

During the course of this study, Decis 5.0 EC was used as a standard of control and water was applied as a check treatment. The trials were carried out at six co-operator sites: Riverbend Plantation (Grace & Lee Whittington, Saskatoon), The Happy Hoer (Cliff Shockey, Vanscoy), Moonlake Berry Farm (Darrel Porter, Saskatoon), a site owned by saskatoon grower/propagator Jarvis Blushke (Langham), the Canada – Saskatchewan Irrigation Diversification Centre (Outlook), and the University of Saskatchewan (Saskatoon). Trials were established at each site using a randomized complete block design (RCBD) with 3 replicates. The rates and application times for each product were based on currently registered rates used in other bush and/or tree fruit crops. In 2000, one kg of fruit was collected from the control, Matador 120 EC and Sevin XLR Plus treatments and sent to Enviro-Test Laboratories in Edmonton for insecticide residue analyses.

Insect populations were very low at all study sites in the 2000 field season. Dry winter weather and long, cool, cloudy springs and early summers likely negatively affected insect survival. The consequence of this low abundance of pest insects was substantial variability in the samples collected for assessment of pest insect presence and damage. As a result, it wasn't possible to assess the efficacy of the insecticides.

The data for the 2001 and 2002 field seasons were more useful. Data collected in these years indicated that Bartlett's Superior 70 Oil provided effective and reliable control of bud moth larvae and reduced damage associated with this pest to very low levels. This was likely due to the fact that Bartlett's Superior 70 Oil was applied after the adult bud moth had deposited its eggs, but prior to the time when the larvae would normally emerge. Product application occurred at approximately the same date during all years, however, spring temperature varied significantly between the 2001 and 2002 seasons where bud break occurred in early-May 2001 and in late-May 2002. Despite these differences, a high level of larval bud moth control was achieved during both seasons. Minor use registration of this product was granted during the 2002 season.

Matador 120 EC and DiPel 2X DF applications partially controlled larval bud moth numbers and damage associated with this pest, although proper timing of

application appeared to be important for these treatments to be effective. The control of bud moth larvae provided by DiPel 2X DF applications was less consistent than the control achieved with the other insecticides tested. More frequent applications may be required to increase the consistency of control provided by DiPel 2X DF. Matador 120 EC was equally effective as Decis 5.0 EC in controlling thrip and larval bud moth numbers, and damage associated with bud moth larvae, leaf rolling caterpillars and larval sawflies. Varying levels of leafroller and thrip control were obtained with applications of Bartlett's Superior 70 Oil, Matador 120EC and DiPel 2X DF. To date, Matador 120 EC provided the most reliable method of control of leaf rolling caterpillars and thrips of any of the pesticides screened in this study. Initial results obtained from screening Success 480 SC were promising. Success 480 SC controlled thrip and larval bud moth numbers and damage associated with bud moth larvae, leaf roller caterpillars and larval sawflies. Assessment for minor use registration of these insecticides is in progress. Sevin XLR Plus was deleted from the study in 2001 on the advice of the Pest Management Regulatory Agency as new crop registrations for this product were being restricted.

There were no indications that any of the products tested in this trial had phytotoxic effects on shoots, leaves, flowers or fruit of the saskatoon. In regards to residue analyses done on fruit samples collected in 2000, all samples from the Matador 120 EC-treated plots had less than the 0.1 ppm cyhalothrin-lambda maximum limit allowed for minor-use registration. Two of the three samples from the Sevin XLR Plus-treated plots had carbaryl residues in excess of the 0.1 ppm maximum limit. The mid- to late- June application of Sevin XLR Plus likely was the cause of these excess residues.

3. Technical Report

3.1. Background

The objective of this project was to screen a number of alternative insecticides suitable for efficacy of control of insect pests in Saskatoon orchards. At the beginning of this study only one insecticide, Decis 5.0 EC, was registered for use against aboveground insect pests in bearing saskatoon orchards. The registration of one or more additional insecticides was important to reduce the risk of insect pests developing resistance to Decis 5.0 EC. In any crop system, reliance on a single insecticide can select for resistant pest insect numbers relatively quickly. Additionally, it has been noted that reliance of Decis 5.0 EC in apple orchards can lead to increasing problems from spider mites, and this appeared to be happening in saskatoon orchards. Finally, Decis 5.0 EC is relatively toxic to mammalian systems and growers must use proper precautions and protection when using this insecticide. Many saskatoon growers would prefer not to use such a toxic insecticide. The registration of substantially less toxic insecticides would therefore increase grower safety. The insecticides screened included dormant oil (Bartlett's Bartlett's Superior 70 Oil), cyhalothrin-lambda (Matador 120 EC), carbaryl (Sevin XLR Plus), spinosad (Success 480 SC), and *Bacillus thuringiensis subsp. kurstaki* (DiPel 2X DF).

3.2. Materials and Methods

3.2.1. Treatment Application

The insecticides screened included dormant oil (Bartlett's Superior 70 Oil), cyhalothrin-lambda (Matador 120 EC), carbaryl (Sevin XLR Plus), spinosad (Success 480 SC), and *Bacillus thuringiensis subsp. kurstaki* (DiPel 2X DF). Decis 5.0 EC, which is currently registered for use on saskatoons, was used as a standard of control and water was applied as a check treatment.

Six sites were used for this trial: Riverbend Plantation (Grace & Lee Whittington, Saskatoon), The Happy Hoer (Cliff Shockey, Vanscoy), Moonlake Berry Farm (Darrel Porter, Saskatoon), a site owed by saskatoon grower/propagator Jarvis Blushke (Langham), the Canada – Saskatchewan Irrigation Diversification Centre (Outlook), and the University of Saskatchewan (Saskatoon). The site at Moonlake Berry Farm was previously owned by an organic grower and had never been treated with any pesticides in the past. It was hoped that this site would have greater insect numbers than sites with a history of insecticide use. Trials were established at each site using a randomized complete block design (RCBD) with 3 replicates. At all the sites except Riverbend Plantation, five plants were used for each treatment and a buffer of two plants was placed between treatments to eliminate drift effects. At Riverbend Plantation, where bushes were very large and not easily defined units, treatments consisted of 4 meters of row. Trials were located on the edge of each orchard site and two untreated buffer rows were placed on the other side of the trial to block spray drift from the rest of the orchard operation.

The saskatoon cultivars used varied among sites. At Riverbend Plantation, F2 seedlings of the cultivar Thiessen were used. Clones of the cultivar Martin were used for the trial at Moonlake Berry Farm. The cultivars Thiessen, JB30 and Elizabeth were present at the Langham site. Micropropagated material of the cultivar Smoky was used at the Outlook site. An assortment of open-pollinated saskatoon seedlings was used at the University of Saskatchewan location.

Several changes from the original project design were made during the course of the study. The insecticide Ambush was replaced with Matador 120 EC under the suggestion of Zeneca Agro. A single rate for each insecticide product was used, rather than two rates, to reduce the size of the trial and to minimize the impact of fruit loss on the co-operators. For the 2001 season, the last application of Sevin XLR Plus was deleted from the study as a result of the high crop residue levels found during the 2000 season. Sevin XLR Plus was removed from the study after the 2001 season when the Pest Management Regulatory Agency indicated that new registrations of this product were being restricted. During the 2002 season this treatment was replaced with Success 480 SC (spinosad).

Treatments were applied using a Model SS CO_2 powered pesticide sprayer (R & D Sprayers Inc., Opelousas, Louisiana). Sprayer pressure was set at 40 PSI and the insecticide treatments were applied through a single TeeJet VisiFlo 8004EVS nozzle. Pesticide mixes were prepared immediately prior to application in the volume required to cover one treatment (5 bushes). Spray volumes were applied uniformly over each treatment. The sprayer was flushed with water between each application of insecticide product to avoid cross contamination of the treatments.

The rates for each product were based on currently registered rates used in other bush and/or tree fruit crops. The water volume used to apply Decis 5.0 EC and Matador 120 EC using ground equipment in similar applications typically ranges between 100-200 L per hectare. The water volume used with Decis 5.0 EC and Matador 120 EC in this trial was increased from the typical volumes described on the product labels to provide more uniform coverage on the crop using hand-held spray equipment. To calculate the per-plant treatment rate, a plant density of 2200 plants per hectare was assumed. The insecticide treatments used in this trial are summarized in the table below.

Product	Rate/ha	Rate/plant
Bartlett's Superior 70 Oil AI: 98.5% Mineral Oil N.M. Bartlett Inc.	2% Bartlett's Superior 70 Oil Solution at 1000 L/ha	455 ml of 2% Bartlett's Superior 70 Oil solution
Decis 5.0 EC 5.0 EC AI: Deltamethrin, 50 g per litre Aventis Cropscience Canada Co.	88 ml Decis 5.0 EC/ha in 600 L water	0.04 ml Decis 5.0 EC in 280 L water
Matador 120 EC AI: Cyhalothrin-lambda, 120g/L Zeneca Agro	104 ml Matador 120 EC/ha in 600 L water	0.05 ml Matador 120 EC in 280 L water
Sevin XLR Plus AI: Carbaryl, 44.1% by wt. Aventis Cropscience Canada Co.	5.25 L Sevin XLR Plus/ha in 1000 L water	2.39 ml Sevin XLR Plus in 455 ml water
Success 480 SC A.I: Spinosad, 480 g per litre Dow AgroSciences Inc.	182 ml Success 480 SC/ha in 1000 L water	0.9 ml Success 480 SC in 455 ml water
DiPel 2X DF AI: *Bacillus thuringiensis subsp. kurstaki*, 32,000 international units per mg Valent BioSciences Canada Ltd.	1400 g DiPel 2X DF in 700 L water	0.64 g DiPel 2X DF in 320 water

AI = active ingredient

The number of insecticide applications varied depending on the product tested. Application times, product rates and the stage of plant development that treatments were applied are summarized in the following tables.

Summary of rate and timing of insecticide treatments, 2000.

Date	Site	Product	Rate	Bud Stage During Treatment
April 28	Riverbend Plantation	Bartlett's Superior 70 Oil	2 % solution at 1000 l/ha	Early silver tip
	The Happy Hoer	Bartlett's Superior 70 Oil		Early silver tip
May 1	J. Blushke	Bartlett's Superior 70 Oil		Early silver tip
May 5	Riverbend Plantation	Decis 5.0 EC	88 ml/ha in 600 L water	Mostly at green tip stage, some at white tip
		Matador 120 EC	104 ml/ha in 600 L water	
		Sevin XLR Plus	5.24 L/ha in 1000 L water	
		DiPel 2X DF	1400 g/ha in 700 L water	
	The Happy Hoer	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Green tip to early white tip
May 6	J. Blushke	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Green tip
May 16	Riverbend Plantation	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Variable from green tip to full bloom. Most around white tip and tube stages.
	The Happy Hoer	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	30-40% bloom
May 23	J. Blushke	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	50-70 bloom
May 30	Riverbend Plantation	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Most at fruit set stage. Some at bloom to petal drop stages.
	The Happy Hoer	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Fruit set
June 5	J. Blushke	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Fruit set
June 12	Riverbend Plantation	Matador 120 EC, Sevin XLR Plus,	As above	Green fruit
	The Happy Hoer	Matador 120 EC, Sevin XLR Plus,	As above	Green fruit
June 19	J. Blushke	Matador 120 EC, Sevin XLR Plus,	As above	Green fruit

Summary of rate and timing of insecticide treatments, 2001.

Date	Site	Product	Rate	Bud Stage During Treatment
April 23	Riverbend Plantation	Bartlett's Superior 70 Oil	2 % solution at 1000 l/ha	Bud break
April 26	Moonlake Berry Farm	Bartlett's Superior 70 Oil		Bud break
	SIDC - Outlook	Bartlett's Superior 70 Oil		Bud break to silver tip
	U of S	Bartlett's Superior 70 Oil		Bud break to silver tip
May 3	Riverbend Plantation	Decis 5.0 EC	88 ml/ha in 600 L water	Early green tip to green tip
		Matador 120 EC	104 ml/ha in 600 L water	
		Sevin XLR Plus	5.24 L/ha in 1000 L water	
		DiPel 2X DF	1400 g/ha in 700 L water	
	Moonlake Berry Farm	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Early green tip
	SIDC - Outlook	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Green tip
	U of S	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Green tip
May 11	U of S	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Variable from white tip to full bloom
May 14	Riverbend Plantation	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Variable from white tip to full bloom
	SIDC - Outlook	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Balloon stage, some tube, some full bloom (generally very uniform)

	Moonlake Berry Farm	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Balloon stage, some tube, some full bloom (generally very uniform)
May 30	Riverbend Plantation	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Most at fruit set stage
	Moonlake Berry Farm	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Fruit set
	SIDC - Outlook	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Fruit set
	U of S	Decis 5.0 EC, Matador 120 EC, Sevin XLR Plus, DiPel 2X DF	As above	Fruit set

Summary of rate and timing of insecticide treatments, 2002.

Date	Site	Product	Rate	Bud Stage During Treatment
April 25	Moonlake Berry Farm	Bartlett's Superior 70 Oil	2 % solution at 1000 l/ha	Bud break
	SIDC - Outlook	Bartlett's Superior 70 Oil		Dormant
	U of S	Bartlett's Superior 70 Oil		Dormant
May 16	U of S	Decis 5.0 EC	88 ml/ha in 600 L water	Bud break to green tip
		Matador 120 EC	104 ml/ha in 600 L water	
		Success 480 SC	5.24 L/ha in 1000 L water	
		DiPel 2X DF	1400 g/ha in 700 L water	
	Moonlake Berry Farm	Decis 5.0 EC, Matador 120 EC, Success 480 SC, DiPel 2X DF	As above	Early green tip
	SIDC - Outlook	Decis 5.0 EC, Matador 120 EC, Success 480 SC, DiPel 2X DF	As above	Early green tip
May 29	U of S	Decis 5.0 EC, Matador 120 EC, Success 480 SC, DiPel 2X DF	As above	Variable from white tip to full bloom
	Moonlake Berry Farm	Decis 5.0 EC, Matador 120 EC, Success 480 SC, DiPel 2X DF	As above	Early full bloom (generally very uniform)
May 30	SIDC - Outlook	Decis 5.0 EC, Matador 120 EC, Success 480 SC, DiPel 2X DF	As above	Full bloom (generally very uniform)
June 14	SIDC - Outlook	Decis 5.0 EC, Matador 120 EC, Success 480 SC, DiPel 2X DF	As above	Fruit set
	Moonlake Berry Farm	Decis 5.0 EC, Matador 120 EC, Success 480 SC, DiPel 2X DF	As above	Fruit set
	U of S	Decis 5.0 EC, Matador 120 EC, Success 480 SC, DiPel 2X DF	As above	Fruit set

3.2.2. Data Collection

During the 2000 season, 5 flower or fruit clusters were arbitrarily sampled from each replicate and treatment, 5 to 7 days following each insecticide application. Shortly after sampling, clusters were examined and insect numbers were determined. Several problems with this sampling method were found. The sample number was too small to evaluate insect density given the low insect numbers of the 2000 season. It was also difficult to identify and count live insects. Several changes were made to the sampling method for the 2001 and 2002 seasons. The sample size was increased to 20 flower or fruit clusters per treatment per insecticide application. Sampling was conducted 5 to 7 days following insecticide application, and clusters were preserved in a storage solution

(ethanol/formalin/acetic acid) so that collection of efficacy data could be conducted during the winter months. The inspection process involved rinsing the sample into a petri dish, where all insects suspended in the solution were identified and counted. Each cluster, including any attached leaves, was then inspected individually under a low-power microscope for the presence of adult insects, eggs, larvae and insect damage. Insect damage was rated according to severity.

During the 2000 and 2001 seasons, 1 kg of fruit was collected from the control, Matador 120 EC and Sevin XLR Plus treatments at each site and sent to Enviro-Test Laboratories in Edmonton for insecticide residue analyses.

3.3. Results and Discussion

3.3.1. 2000 Field Season

Insect populations were very low at all study sites in the 2000 field season. Dry winter weather and long, cool, cloudy springs and early summers likely negatively affected insect survival. The consequence of this low abundance of pest insects was substantial variability in the samples collected for assessment of pest insect presence and damage. As a result, it wasn't possible to assess the efficacy of the insecticides. Figures 1 through 11 illustrate the comparison among the treatments relative to the percentage of flower, fruit or leaf clusters containing pest insects or with damage. Certain trends are evident, but the differences were not statistically significant. For example, for thrips, the control samples from Riverbend and Moonlake contained substantially higher numbers, and the applications of Decis 5.0 EC and Matador 120 EC tended to reduce these numbers (Figures 4 and 5). In regards to apple curculio damage, Figures 7, 8 and 9 suggest that Decis 5.0 EC and Matador 120 EC were effective at controlling this pest insect, but again, the data were too variable to statistically assess efficacy.

3.3.2. 2001 Field Season

3.3.2.1. Bartlett's Superior 70 Oil

Bartlett's Superior 70 Oil was a very effective treatment for larval bud moth control, reducing the average number of this pest from one bud moth in every second flower cluster to one bud moth in every fifty flower clusters sampled at Moonlake Berry Farm on May 9, 2001 (Table 1). At this site, the number of flower clusters with bud moth damage was reduced from 46.7% in the control group to 1.7 % in the plants treated with Bartlett's Superior 70 Oil (Table 1). The number of flower clusters detected with bud moth damage at the University of Saskatchewan site during the May 9th sampling period was reduced from 20.3 % in the control group to 8.0 % in plants treated with Bartlett's Superior 70 Oil (Table 3). Samples collected from Moonlake Berry Farm on May 17th had bud moth damage to 28.3 % of the flower clusters in the untreated plants while those

treated with Bartlett's Superior 70 Oil had bud moth damage to 3.3 % of the flower clusters (Table 5).

Samples collected on May 17th from the Riverbend Plantation showed a significant reduction in leafroller damage to the Bartlett's Superior 70 Oil treatment (7.5% of clusters) relative to the control group (27.8% of clusters) (Table 4).

3.3.2.2. DiPel 2X DF

Samples collected from Moonlake Berry Farm on May 17th had bud moth damage to 28.3 % of the flower clusters of the control group while those treated with DiPel 2X DF had bud moth damage to 13.3 % of the clusters (Table 5). Samples collected on May 9th, after the first application of Dipel 2X DF, showed no differences between the control and DiPel 2X DF treatments in terms of bud moth number or frequency of bud moth damage. It is possible that DiPel 2X DF was ineffective at penetrating the flower cluster at the green tip stage of flower development and the bud moth larvae were protected at this time.

Samples collected on May 9th from the University of Saskatchewan had leafroller damage to 20.3 % of the flower clusters in untreated plants while none of the flower clusters sampled from the DiPel 2X DF treatment had any leafroller damage (Table 3). Samples collected on May 17th from the Riverbend Plantation showed a significant reduction in the extent of leafroller damage to the DiPel 2X DF treatments relative to the control group (Table 4). In clusters showing leafroller damage, 27.8 % of the flower buds from the control group were damaged, while only 3.0 % of the flower buds treated with DiPel 2X DF were damaged.

3.3.2.3. Matador 120 EC

Matador 120 EC and Decis 5.0 EC were the only insecticides tested during the 2001 season that reduced thrip numbers in the flower clusters (Tables 1, 2 & 6). At the Moonlake Berry Farm site, samples collected on May 9th had average thrip numbers of one thrip in every flower cluster in the control group but in samples treated with Matador 120 EC, the thrip number was reduced to one thrip in fifty flower clusters (Table 1). At the Outlook location, thrip numbers in samples collected on May 9th showed a 16 fold reduction in Matador 120 EC treated plants relative to the control group (Table 2). At this same location, samples collected on May 17th showed a 65 fold reduction in thrip numbers in the Matador 120 EC treated plants relative to untreated plants (Table 3).

Matador 120 EC was also effective at reducing larval bud moth numbers and reducing feeding damage to flower buds caused by bud moth larvae. Samples collected on May 9th at Moonlake Berry Farm had on average one larval bud moth in every second cluster while those treated with Matador 120 EC had a larval bud moth in every seven clusters (Table 1). This product was more effective than Decis 5.0 EC but less effective

than Bartlett's Superior 70 Oil at reducing bud moth numbers. The percentage of clusters showing larval bud moth damage was reduced from 46.7 % in the control group to 10.0 % in those treated with Matador 120 EC. Samples collected from Moonlake Berry Farm during the May 17th sampling period had larval bud moth damage to 28.3 % of the flower clusters in the control group while those treated with Matador 120 EC had larval bud moth damage to 5.0 % of the clusters (Table 5).

Samples collected on May 17th from the Riverbend Plantation showed a significant reduction in the extent of leafroller damage to the Matador 120 EC treatment relative to the control group. Of flower clusters showing leafroller damage, 27.8 % of the flower buds in the control group were damaged, while those treated with Matador 120 EC only had damage to 3.7 % of the flower buds (Table 4). Similar results were observed at the University of Saskatchewan in samples collected on June 4th. Among the fruit clusters showing leafroller damage, 22.7 % of fruit in the control group had leafroller damage while the fruit treated with Matador 120 EC were undamaged (Table 7).

3.3.3. 2002 Field Season

3.3.3.1. Bartlett's Superior 70 Oil

Bartlett's Superior 70 Oil was effective at reducing the frequency and severity of larval bud moth damage (Table 8). Samples collected on May 23, 2002 at the University of Saskatchewan site had larval bud moth damage to 21.7% of the untreated clusters compared with larval bud moth damage to 6.7% of the flower clusters in plants where Bartlett's Superior 70 Oil was applied. Among the damaged clusters, 36.7% of the untreated flower buds were chewed by bud moth larvae, however, only 3.3% of the flowers were chewed where Bartlett's Superior 70 Oil was applied. A reduction in larval bud moth numbers also was observed in the Bartlett's Superior 70 Oil treatment in samples collected at the Moonlake Berry Farm site (Table 10).

There was some evidence that thrip numbers can be controlled by this treatment (Tables 9, 10 & 12). However, no thrip control was observed in samples collected from the University of Saskatchewan on June 4, 2002 (Table 11).

Some larval sawfly control was observed at the Outlook site in samples treated with Bartlett's Superior 70 Oil, collected on June 4, 2002 (Table 12) but this treatment was not effective at the University of Saskatchewan (Table 11).

3.3.3.2. DiPel 2X DF

Samples collected during the 2002 season indicated that DiPel 2X DF can effectively control bud moth larvae, but control was less reliable than that obtained with other products tested. Samples collected from Moonlake Berry Farm on May 23, 2002 had fewer bud moth larvae than untreated samples (Table 10). DiPel 2X DF was less

effective in controlling bud moth damage than the other products tested in samples collected from the University of Saskatchewan site in May 23, 2002 (Table 8).

Flower clusters collected from the Moonlake Berry Farm on May 23, 2002 had fewer thrips in samples treated with DiPel 2X DF than samples from untreated plants. However, during other sampling periods, thrip numbers were unaffected by the DiPel 2X DF treatment.

3.3.3.3. Matador 120 EC

Matador 120 EC effectively controlled thrip and bud moth numbers and damage associated with bud moth larvae, leaf roller caterpillars and sawfly larvae. Untreated samples collected at the University of Saskatchewan site on May 23, 2002 had bud moth damage to 21.7% of the flower clusters, however, only 1.7% of the Matador 120 EC treated samples had bud moth damage. Among these damaged clusters, 36.7% of the flower buds of the untreated samples were chewed, while only 3.3% of the flowers were chewed in the Matador 120 EC treated samples. Samples collected from untreated plants at Moonlake Berry Farm on May 23, 2002 had, on average, 1 larval bud moth in every 6 flower clusters, however no bud moth larvae were found in Matador 120 EC treated cluster samples.

Matador 120 EC consistently reduced thrip numbers in samples collected from the test sites used during the 2002 season (Table 9 – Table 12).

Larval sawfly damage was reduced in samples collected from the University of Saskatchewan and Outlook on June 4, 2002. Fruit clusters collected from the University of Saskatchewan had larval sawfly damage to 23.3% of the fruit clusters while only 1.6% of the fruit clusters treated with Matador 120 EC had any larval sawfly damage (Table 11). Samples collected from the Outlook site had some larval sawfly damage to 56.0% of the fruit clusters while only 28.3% of the flower clusters treated with Matador 120 EC had larval sawfly damage (Table 12).

Damage associated with leaf rolling caterpillar feeding was reduced from 18.3% of fruit clusters in untreated plants to 0% in Matador 120 EC treated plants sampled on June 20, 2002 at the University of Saskatchewan (Table 13).

3.3.3.4. Success 480 SC

Initial results with Success 480 SC were promising. Success 480 SC controlled thrip and larval bud moth numbers and damage, leaf roller caterpillars, and sawfly larvae. Untreated samples collected at the University of Saskatchewan site on May 23, 2002 had bud moth damage to 21.7% of the flower clusters, whereas 0% of the Success 480 SC treated samples had larval bud moth damage (Table 8). Among these damaged clusters, 36.7% of the flowers of the untreated samples were chewed, whereas only 3.3% of the

flowers were chewed in the Success 480 SC treated samples. Samples collected from untreated plants at Moonlake Berry Farm on May 23, 2002 had, on average, 1 larval bud moth in every 6 flower clusters, while larval bud moth numbers were reduced by approximately 3 times in plants treated with Success 480 SC.

Success 480 SC consistently reduced thrip numbers in samples collected from the test sites used during the 2002 season (Table 9, 10 & 12).

Larval sawfly damage was reduced in samples collected from the University of Saskatchewan and Outlook on June 4, 2002. Fruit clusters collected from the University of Saskatchewan had some larval sawfly damage to 23.3% of the fruit clusters, while only 8.3% of Success 480 SC - treated fruit clusters had any larval sawfly damage (Table 11). Fruit clusters collected at Outlook on June 4, 2002 had some larval sawfly damage to 56.0% of the fruit clusters while 28.3% of Success 480 SC treated fruit clusters had larval sawfly damage (Table 12).

Damage associated with leafroller feeding was reduced from 18.3% of the fruit clusters sampled in untreated plants to 0% in plants treated with Success 480 SC sampled on June 20, 2002 at the University of Saskatchewan (Table 13).

Table 1. Effect of insecticide treatment on insect numbers and damage to saskatoon flower clusters collected May 9, 2001, Moonlake Berry Farm, Saskatoon, SK.

Treatment	Mean number of bud moth larvae/cluster	Mean % of flower clusters/sample with larval bud moth damage	Mean % of flower clusters/sample with leafroller damage	Mean % of flowers/cluster with leafroller damage	Mean number of thrips/cluster
Control	0.47 a	46.7 a	16.7 b	11.6 a	1.13 ab
DiPel 2X DF	0.58 a	43.3 a	30.0 a	8.4 a	1.37 a
Sevin XLR Plus	0.17 bc	16.7 b	8.3 b	6.7 a	0.57 c
Matador 120 EC	0.15 bc	10.0 bc	6.7 b	5.9 a	0.02 d
Decis 5.0 EC	0.42 ab	18.3 b	11.7 b	8.4 a	0.05 d
Bartlett's Superior 70 Oil	0.02 c	1.7 c	6.7 b	5.5 a	0.81 bc

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.
c) Mean % of flowers/cluster with leafroller damage shows the extent of damage to the flower cluster from samples that had some chewing damage.

Table 2. Effect of insecticide treatment on thrip numbers in saskatoon flower clusters collected May 9, 2001, Canada-Saskatchewan Irrigation Diversification Centre, Outlook, SK.

Treatment	Mean number of thrips/cluster
Control	2.8 ab
DiPel 2X DF	3.5 a
Sevin XLR Plus	0.83 c
Matador 120 EC	0.17 c
Decis 5.0 EC	0.08 c
Bartlett's Superior 70 Oil	2.5 b

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.

Table 3. Effect of insecticide treatment on insect numbers and damage to saskatoon flower clusters collected May 9, 2001, University of Saskatchewan, Saskatoon, SK.

Treatment	Mean % of flower clusters/sample with larval bud moth damage	Mean % of flower clusters/sample with leafroller damage	Mean % of flowers/cluster with leafroller damage	Mean number of thrips/cluster
Control	20.3 a	8.3 a	22.0 a	0.15 b
DiPel 2X DF	0 b	0 b	5.6 a	0.42 a
Sevin XLR Plus	5.8 b	1.7 b	5.4 a	0 b
Matador 120EC	8.4 ab	5.0 ab	0 a	0 b
Decis 5.0 EC	0 b	0 b	0 a	0.02 b
Bartlett's Superior 70 Oil	8.0 b	0 b	0 a	0.20 ab

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.

Table 4. Effect of insecticide treatment on insect damage to saskatoon flower clusters collected May 17, 2001, Riverbend Plantation, Saskatoon, SK.

Treatment	Mean % of flower clusters/sample with leafroller damage	Mean % of flowers/cluster with leafroller damage
Control	11.7 a	27.8 a
DiPel 2X DF	5.2 a	3.0 b
Sevin XLR Plus	3.4 a	7.5 b
Matador 120EC	3.3 a	3.7 b
Decis 5.0 EC	3.3 a	14.8 ab
Bartlett's Superior 70 Oil	1.7 a	7.5 b

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$). Each sample consisted of 20 flower clusters.
b) Mean % of fruit/cluster with leafroller damage shows the extent of damage to the flower cluster from samples that had some chewing damage.

Table 5. Effect of insecticide treatment on insect damage to saskatoon flower clusters collected May 17, 2001, Moonlake Berry Farm, Saskatoon, SK.

Treatment	Mean % of flower clusters/sample with larval bud moth damage
Control	28.3 a
DiPel 2X DF	13.3 b
Sevin XLR Plus	6.7 b
Matador 120EC	5.0 b
Decis 5.0 EC	5.0 b
Bartlett's Superior 70 Oil	3.3 b

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$). Each sample consisted of 20 flower clusters.

Table 6. Effect of insecticide treatment on thrip numbers in saskatoon flower clusters collected May 17, 2001, Saskatchewan Irrigation Diversification Centre, Outlook, SK.

Treatment	Mean number of thrips/cluster
Control	5.25 ab
DiPel 2X DF	8.75 a
Sevin XLR Plus	1.5 c
Matador 120EC	0.08 c
Decis 5.0 EC	0.07 c

Bartlett's Superior 70 Oil	4.77 b

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.

Table 7. Effect of insecticide treatment on insect damage to saskatoon fruit clusters collected June 4, 2001, University of Saskatchewan, Saskatoon, SK.

Treatment	Mean % of fruit clusters/sample with leafroller damage	Mean % of fruit/cluster with leafroller damage
Control	8.4 a	22.7 a
DiPel 2X DF	8.3 a	24.4 a
Sevin XLR Plus	1.7 a	3.7 b
Matador 120EC	0 a	0 b
Decis 5.0 EC	3.3 a	4.4 b
Bartlett's Superior 70 Oil	8.3 a	8.8 ab

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.
c) Mean % of fruit/cluster with leafroller damage shows the extent of damage to the fruit cluster from samples that had some chewing damage.

Table 8. Effect of insecticide treatment on insect damage to saskatoon flower clusters collected May 23, 2002, University of Saskatchewan, Saskatoon, SK.

Treatment	Mean % of flower clusters/sample with larval bud moth chewing damage	Mean % of flower clusters/sample with larval bud moth holes
Control	21.7 a	36.7 a
DiPel 2X DF	11.8 ab	20.1 ab
Success 480SC	0 b	6.7 b
Matador 120EC	1.7 b	3.3 b
Decis 5.0 EC	0 b	3.3 b
Bartlett's Superior 70 Oil	6.7 b	3.3 b

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.

Table 9. Effect of insecticide treatment on thrip numbers in saskatoon flower clusters collected May 23, 2002, Saskatchewan Irrigation Diversification Centre, Outlook, SK.

Treatment	Mean number of thrips/cluster
Control	1.44 a
DiPel 2X DF	0.95 ab
Success 480 SC	1.13 a
Matador 120EC	0.13 c
Decis 5.0 EC	0.15 c
Bartlett's Superior 70 Oil	0.46 bc

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.

Table 10. Effect of insecticide treatment on insect damage to saskatoon flower clusters collected May 23, 2002, Moonlake Berry Farm, Saskatoon, SK.

Treatment	Mean number of bud moth larvae/cluster	Mean number of thrips/cluster
Control	0.17 a	0.38 a
DiPel 2X DF	0.02 b	0.15 b
Success 480SC	0.05 b	0.20 ab
Matador 120EC	0 b	0.03 b
Decis 5.0 EC	0 b	0.08 b
Bartlett's Superior 70 Oil	0 b	0.12 b

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.

Table 11. Effect of insecticide treatment on insect damage to saskatoon fruit clusters collected June 4, 2002, University of Saskatchewan, Saskatoon, SK.

Treatment	Mean number of thrips/cluster	Mean % of flower clusters/sample with larval sawfly damage
Control	0.77 a	23.3 ab
DiPel 2X DF	1.1 a	16.7 abc
Success 480SC	0.65 ab	8.3 c
Matador 120EC	0.33 b	1.6 c
Decis 5.0 EC	0 b	3.3 c
Bartlett's Superior 70 Oil	0.77 a	27.1 a

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.

Table 12. Effect of insecticide treatment on insect damage to saskatoon fruit clusters collected June 4, 2002, Outlook, Saskatoon, SK.

Treatment	Mean number of thrips/cluster	Mean % of flower clusters/sample with larval sawfly damage
Control	5.42 a	56.0 a
DiPel 2X DF	3.95 ab	21.7 b
Success 480SC	1.17 c	28.3 b
Matador 120EC	0.15 c	28.3 b
Decis 5.0 EC	0.07 c	5 b
Bartlett's Superior 70 Oil	2.07 bc	13.3 b

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.

Table 13. Effect of insecticide treatment on insect damage to saskatoon fruit clusters collected June 20, 2002, University of Saskatchewan, Saskatoon, SK.

Treatment	Mean % of fruit clusters/sample with leafroller damage
Control	18.3 a
DiPel 2X DF	17.2 a
Success 480SC	0 b
Matador 120EC	0 b
Decis 5.0 EC	0 b
Bartlett's Superior 70 Oil	6.8 ab

a) Different letters within a column indicate significant treatment differences. LSD test ($p \leq 0.05$).
b) Each sample consisted of 20 flower clusters.

3.3.4. Evidence of Phytotoxicity

There were no indications that any of the products tested in this trial had phytotoxic effects on shoots, leaves, flowers or fruit of the saskatoon.

3.3.5. Insecticide Residue Analyses

In regards to residue analyses done on fruit samples in 2000, all samples from the Matador 120 EC-treated plots had less than the 0.1 ppm cyhalothrin-lambda maximum

limit allowed for minor-use registration; the highest value obtained for cyhalothrin-lambda residues was 0.0183 ppm. Two of the three samples from the Sevin XLR Plus-treated plots had carbaryl residues in excess of the 0.1 ppm maximum limit (0.487 and 0.348 ppm); only 1 of the samples had less than this limit (0.0955 ppm). The mid- to late-June application of Sevin XLR Plus likely was the cause of these excess residues. The report from Enviro-Test laboratories is appended.

3.4. Conclusions

Insect populations were very low at all study sites in the 2000 field season. Dry winter weather and long, cool, cloudy springs and early summers likely negatively affected insect survival. The consequence of this low abundance of pest insects was substantial variability in the samples collected for assessment of pest insect presence and damage. As a result, it wasn't possible to assess the efficacy of the insecticides.

The results of this study indicated that Bartlett's Superior 70 Oil provided effective and reliable control of bud moth larvae and reduced damage associated with this pest to very low levels. This was likely due to the fact that Bartlett's Superior 70 Oil was applied after the adult bud moth has deposited its eggs, but prior to the time when the larvae would normally emerge. Product application occurred at approximately the same date during all years, however, spring temperature varied significantly between the 2001 and 2002 seasons where bud break occurred in early-May 2001 and in late-May 2002. Despite these differences, a high level of larval bud moth control was achieved during both seasons. Minor use registration of this product was granted during the 2002 season.

Matador 120 EC and DiPel 2X DF applications partially controlled larval bud moth numbers and damage associated with this pest, although proper timing of application appears to important for these treatments to be effective. The control of bud moth larvae provided by DiPel 2X DF applications was less consistent than the control achieved with the other insecticides tested. More frequent applications may be required to increase the consistency of control provided by Dipel 2X DF. Matador 120 EC was equally effective as Decis 5.0 EC in controlling thrip and larval bud moth numbers and damage, leaf rolling caterpillars and larval sawflies. Varying levels of leafroller and thrip control were obtained with applications of Bartlett's Superior 70 Oil, Matador 120 EC and DiPel 2X DF. To date, Matador 120 EC provided the most reliable method of control of leaf rolling caterpillars and thrips of any of the pesticides screened in this study. Initial results obtained from screening Success 480 SC were promising. Success 480 SC controlled thrip and larval bud moth numbers and damage associated with bud moth larvae, leaf roller caterpillars and larval sawflies. Assessment for minor use registration of these insecticides is in progress. Sevin XLR Plus was deleted from the study in 2001 on the advice of the Pest Management Regulatory Agency as new crop registrations for this product were being restricted.

There were no indications that any of the products tested in this trial had phytotoxic effects on shoots, leaves, flowers or fruit of the saskatoon. In regards to

residue analyses done on fruit samples in 2000, all samples from the Matador 120 EC-treated plots had less than the 0.1 ppm cyhalothrin-lambda maximum limit allowed for minor-use registration. Two of the three samples from the Sevin XLR Plus-treated plots had carbaryl residues in excess of the 0.1 ppm maximum limit. The mid- to late- June application of Sevin XLR Plus likely was the cause of these excess residues.

4. PERSONNEL

R. St-Pierre - 5%
H. Tulloch - 25%
J. Hall - 10 %
M. Scholten - 50%
R. Ingram - 5%
A. Krahn - 5%
S. Anwender - 5%
M. Rude - 5%

5. EQUIPMENT

Rented: Munckhof sprayer; Leica stereoscope.

6. PROJECT DEVELOPED MATERIALS

Papers In Non-refereed Journals

Tulloch, H. and R.G. St-Pierre. 2001. Maximizing the Effectiveness of Insecticides and Fungicides Registered for Aboveground Use in Saskatoon Orchards. The Prairie Fruit Journal 8(2):6-9.

Reports

St-Pierre, R.G. 2002. Screening of Insecticides For Use in Saskatoon Orchards to Reduce Risk of Insect Pest Resistance to Decis 5.0 EC and to Increase Grower Safety. Progress Report - January 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

St-Pierre, R.G. 2001. Screening of Insecticides For Use in Saskatoon Orchards to Reduce Risk of Insect Pest Resistance to Decis 5.0 EC and to Increase Grower Safety. Progress Report - January 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

Invited Presentations

St-Pierre, R.G. 2001. Native Fruit Development Program - Research Highlights 2001. Saskatchewan Fruit Growers' Association Annual Conference, Saskatoon, SK. November 23-24.

St-Pierre, R.G. 2001. Integrated pest management for Saskatchewan fruit orchards. Saskatchewan Fruit Growers' Association Annual Conference, Saskatoon, SK. November 23-24.

St-Pierre, R.G. 2001. Using pesticides in saskatoon orchards - why, what & when? Alberta Horticultural Congress, Edmonton, AB. November 8-10.

7. PROJECT PHOTOS

None useful to include in Report.

8. ACKNOWLEDGEMENT

Papers In Non-refereed Journals

Tulloch, H. and R.G. St-Pierre. 2001. Maximizing the Effectiveness of Insecticides and Fungicides Registered for Aboveground Use in Saskatoon Orchards. The Prairie Fruit Journal 8(2):6-9.

Reports

St-Pierre, R.G. 2002. Screening of Insecticides For Use in Saskatoon Orchards to Reduce Risk of Insect Pest Resistance to Decis 5.0 EC and to Increase Grower Safety. Progress Report - January 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

St-Pierre, R.G. 2001. Screening of Insecticides For Use in Saskatoon Orchards to Reduce Risk of Insect Pest Resistance to Decis 5.0 EC and to Increase Grower Safety. Progress Report - January 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

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St-Pierre, R.G. 2001. Using pesticides in saskatoon orchards - why, what & when? Alberta Horticultural Congress, Edmonton, AB. November 8-10.

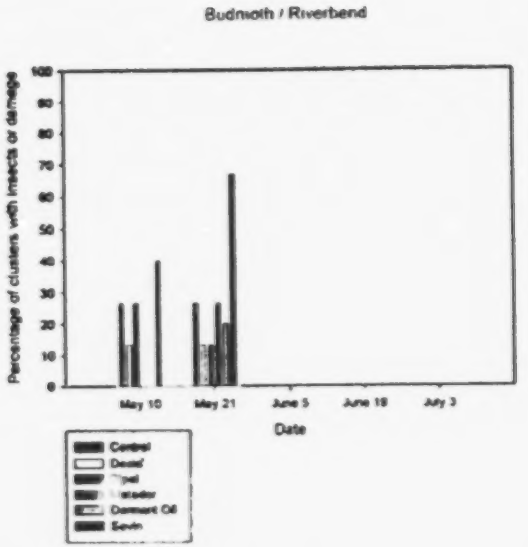

Figure 1 Percentage of saskatoon flower, fruit and leaf clusters with budmoth insects or budmoth damage following applications of 5 different insecticide treatments at Riverbend

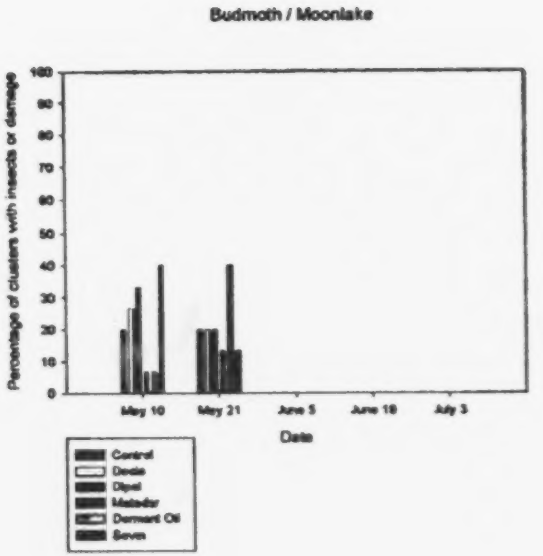

Figure 2 Percentage of saskatoon flower, fruit and leaf clusters with budmoth insects or budmoth damage following applications of 5 different insecticide treatments at Moonlake

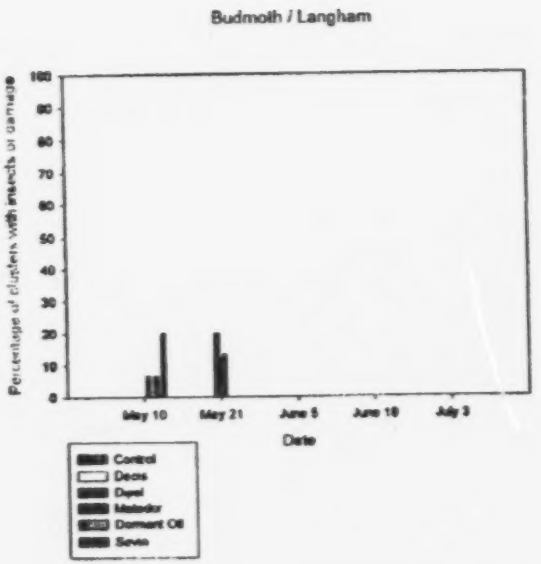

Figure 3 Percentage of saskatoon flower, fruit and leaf clusters with budmoth insects or budmoth damage following applications of 5 different insecticide treatments at Langham

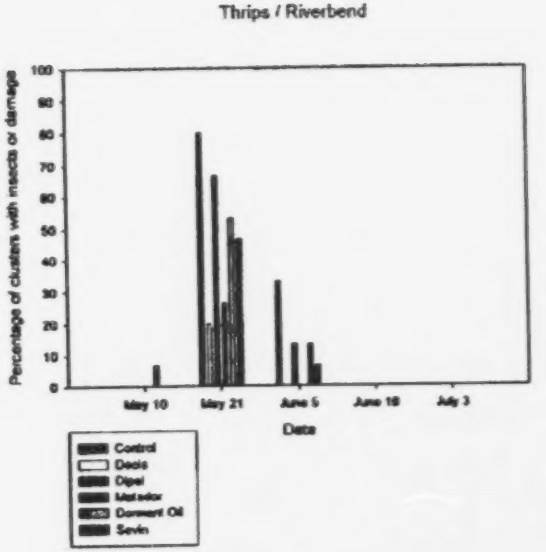

Figure 4 Percentage of saskatoon flower, fruit and leaf clusters with thrips or thrips damage following applications of 5 different insecticide treatments at Riverbend

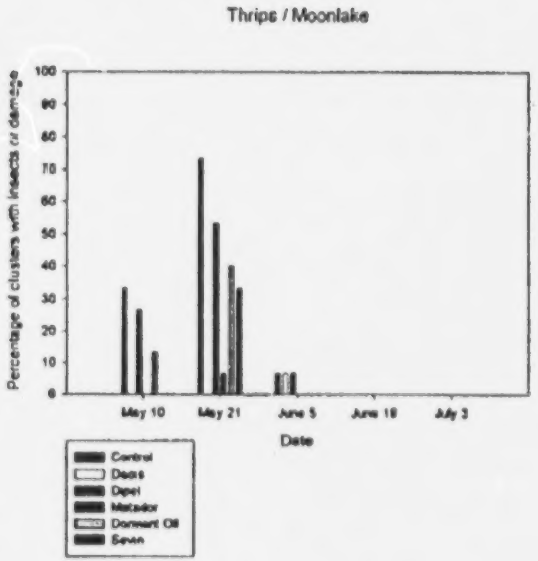

Figure 5 Percentage of saskatoon flower, fruit and leaf clusters with thrips or thrip damage following applications of 5 different insecticide treatments at Moonlake

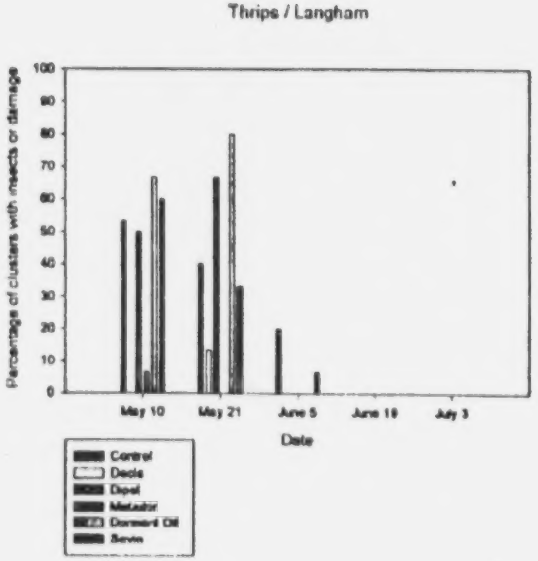

Figure 6 Percentage of saskatoon flower, fruit and leaf clusters with thrips or thrip damage following applications of 5 different insecticide treatments at Langham

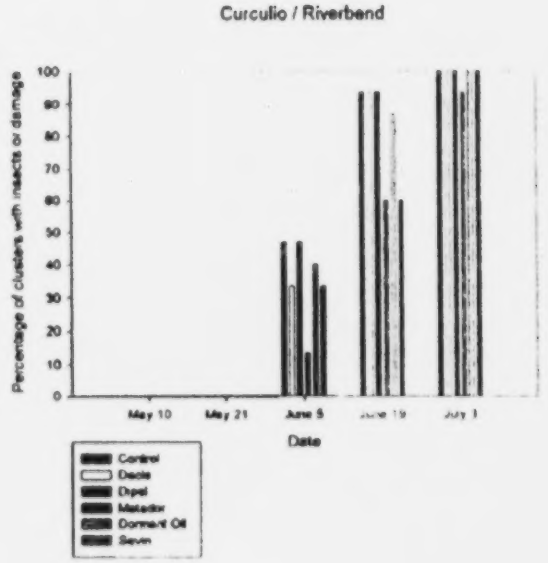

Figure 7 Percentage of oriental fruit moth, fruit and leaf clusters with apple curculio or apple curculio damage following application of 5 different insecticide treatments at Riverbend

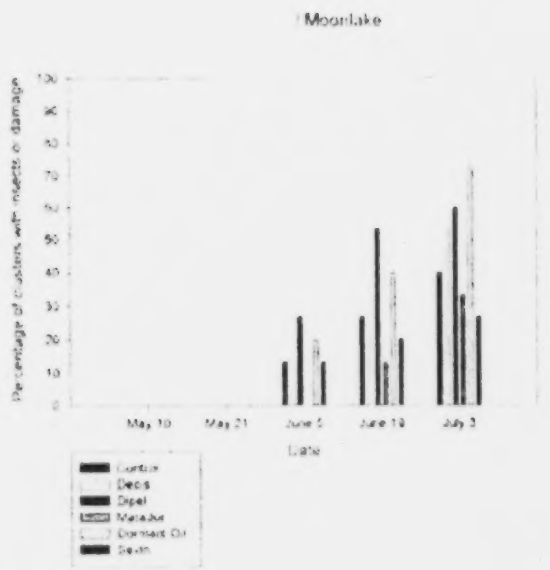

Figure 8 Percentage of oriental fruit moth, fruit and leaf clusters with apple curculio or apple curculio damage following application of 5 different insecticide treatments at Moonlake

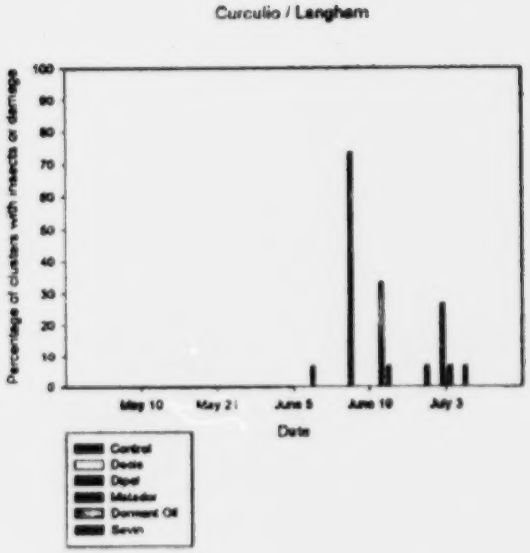

Figure 9 Percentage of saskatoon flower, fruit and leaf clusters with apple curculio or apple curculio damage following applications of 5 different insecticide treatments at Langham

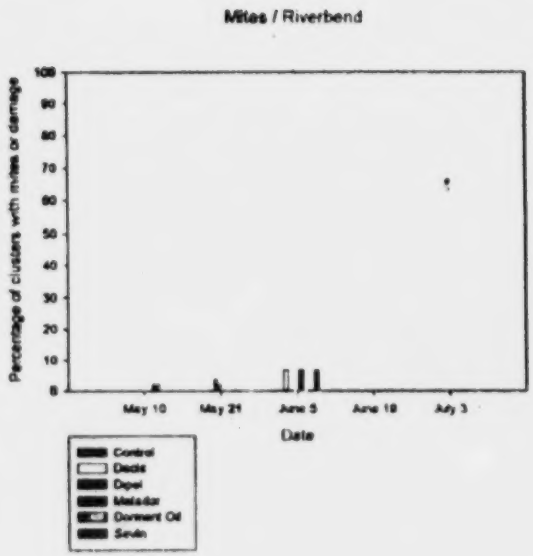

Figure 10 [illegible] fruit and leaf clusters with mites or mite damage following [illegible] treatments at Riverbend

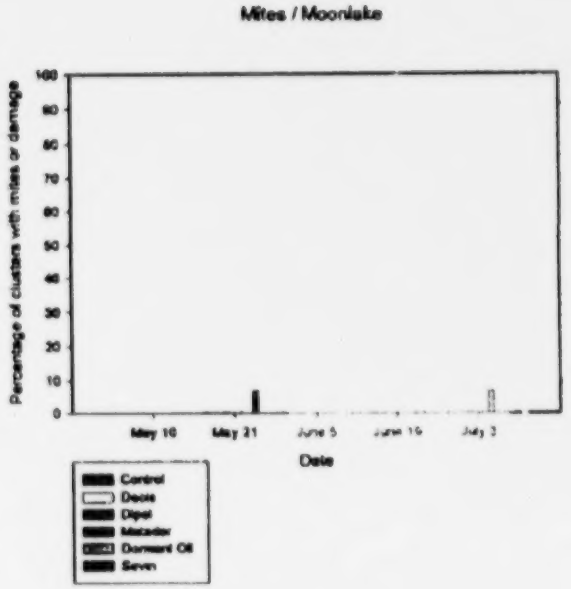

Figure 11 Percentage of saskatoon flower, fruit and leaf clusters with mites or mite damage following applications of 5 different insecticide treatments at Moonlake